Chapter 12-7-3
FIRE-RESISTIVE STANDARDS
FIRE TESTING FURNACES
STANDARD 12-7-3

STATE FIRE MARSHAL Scope Sec. 12-7-300. This standard sets forth the general requirements for the design and control of fire testing furnaces intended for fire exposure testing and assignment of fire endurance ratings of building materials, assemblies of building materials, equipment and devices.

Furnace Design and Dimensions Sec. 12-7-301. Furnaces shall consist of a furnace chamber and an insulated specimen frame. The furnace chamber walls and floor shall consist of insulating fire brick or equivalent heat-reflective materials. Furnace dimensions shall be not less than shown in the following:

(a) **Vertical Large-scale Wall Furnace.** The furnace exposure panel or door shall consist of an insulated steel restraining frame having an available opening for the test sample of not less than 200 square feet in area with neither dimension less than 9 feet.

(b) **Vertical Half-scale Wall Furnace.** The furnace exposure panel or door shall consist of an insulated steel restraining frame having an available opening of not less than 50 square feet for the test sample. Neither dimension of the furnace opening shall be less than 7 feet.

(c) **Horizontal Large-scale Floor Furnace.** The furnace exposure panel shall consist of an insulated steel restraining frame having an available opening of not less than 180 square feet for the test sample. Neither dimension of the furnace opening shall be less than 12 feet.

(d) **Horizontal Small-scale Furnace.** The furnace exposure panel shall consist of an insulated frame having an available opening of not less than 35 square feet for the test sample. Neither dimension of the furnace opening shall be less than 5 feet.

(e) **Horizontal Large-scale Beam Furnace.** The furnace exposure panel shall consist of an insulated steel restraining frame having an available opening of not less than 180 square feet for the test sample. Neither dimension of the furnace opening shall be less than 5 feet.

(f) **Horizontal Small-scale Beam Furnace.** The furnace exposure panel for the "Alternate Test of Protection for Structural Steel Beams, Girders and Trusses" shall consist of an insulated steel frame having an available opening of not less than 35 square feet for the test sample. Neither dimension of the furnace opening shall be less than 5 feet.

(g) **Column Furnace.** The column furnace shall be of such dimensions as to provide an opening for column sections not less than 8 feet in clear length.

(h) **Protection of Equipment and Test Specimen.** The testing furnaces, equipment and test specimen undergoing the fire test shall be protected from any condition of wind or weather, that might lead to abnormal results. The ambient air temperature of the testing room at the beginning of the test shall be within the range of 50◈F to 90◈F (10◈C to 32◈C). Velocity of air across the unexposed face of the test specimen shall not exceed 4.4 feet per second, as determined by an anemometer placed at right angles to the unexposed surface, measured before or during the test. If mechanical ventilation is

employed during the test, an airstream shall not be directed across the surface of the specimen.

Burners and Fuel Sec. 12-7-302.

(a) **Burners.**

1. In vertical furnaces, burners shall be placed in the back wall of the furnace. The location of the burners and provisions for combustion air shall be such as to provide an even flame exposure to the entire exposed face of the test specimen. Combustion air openings shall be provided in such a manner as to normally prevent induction of combustion air through any opening in the test specimen.

2. In horizontal furnaces, burners shall be placed in the floor or side walls. Burrs and the provisions for combustion air shall be so arranged as to provide a uniform exposure to the entire exposed face of the test specimen.

3. In column furnaces, burners shall be placed in the four walls to provide an even luminous flame exposure to all sides of the test sample.

(b) **Fuel.** Furnaces shall be supplied with natural, manufactured or bottled gas.

Time-temperature Curve Sec. 12-7-303. The conduct of fire tests of materials, assemblies, methods of construction, equipment and devices shall be controlled to conform to the applicable portion of the standard time- temperature curve shown in Figure 12-7-3-1. The points on the curve that determine its character are:

1000◈F (538◈C) at 5 minutes

. . . . . .

1300◈F (704◈C) at 10 minutes

. . . . . .

1500◈F (843◈C) at 30 minutes

. . . . . .

1700◈F (927◈C) at 1 hour

. . . . . .

1792◈F (978◈C) at 11/2 hours

. . . . . .

1850◈F (1010◈C) at 2 hours

. . . . . .

1925◈F (1052◈C) at 3 hours

. . . . . .

2000◈F (1093◈C) at 4 hours.

. . . . . .

For a closer definition of the time-temperature curve, see Table 12-7-3A.

Furnace Control Sec. 12-7-304.

(a) **Thermocouples.**

1. Furnace thermocouples shall be protected by sealed porcelain tubes having 3/4-inch outside diameter and 1/8-inch wall thickness, or, as an alternate, in the case of base-metal thermocouples, shall be protected by 1/2-inch wrought steel or wrought iron pipe of standard weight or equivalent protection of approved type.

The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 inches.

2. In the large-scale horizontal floor and vertical wall furnaces, the temperature of the fire test exposure shall be deemed to be the average temperature obtained from the readings

of not less than nine thermocouples symmetrically disposed and distributed to show the temperature near all parts of the test specimen. In the vertical half scale and horizontal small-scale furnaces, the number of thermocouples shall be proportioned to those of the large-scale furnaces, but shall in no case be less than four thermocouples.

3. In the column furnace, the temperature of the fire test exposure shall be deemed to be the average temperature obtained from the readings of not less than eight thermocouples symmetrically disposed at two levels to show the temperature near all parts of the test specimen. The two levels shall be located approximately 2 feet from the top and bottom of an 8 foot clear height furnace.

4. In the vertical wall furnaces, the junction of the thermocouples shall be placed 6 inches from the exposed face of the test specimen at the beginning of the test. The junction of the thermocouples shall, during the fire test and as a result of deflection, be maintained at 6 inches from the exposed face of the test specimen.

5. In horizontal beam, floor and roof furnaces having a furnace chamber not less than 180 square feet in area, the junction of the thermocouples shall be 12 inches from the exposed face of the test specimen at the beginning of the test, and shall not touch the test specimen during the test as a result of its deflection.

6. In horizontal beam, floor and roof furnaces having a furnace chamber less than 180 square feet in area, the junction of the thermocouples shall be placed 6 inches from the exposed face of the test specimen at the beginning of the test and, during the test, shall not touch the test specimen as a result of its deflection.

(b) **Temperature Recording.** The furnace temperatures shall be read at intervals not exceeding 5 minutes during the first 2 hours, and thereafter the intervals may be increased to not more than 10 minutes.

(c) **Furnace Control Accuracy.** The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the thermocouple readings, is within 10 percent of the corresponding area under the standard time-temperature curve for fire tests of 1 hour or less duration, within 7.5 percent for those over 1 hour and not more than 2 hours, and within 5 percent for tests exceeding 2 hours in duration. Individual thermocouple readings shall not exceed or fall below the standard time-temperature curve by more than 15 percent.

(d) **Furnace Correction.** When the indicated resistance period is 1/2 hour or over, determined by the average or maximum temperature rise on the unexposed surface or within the test sample, or by failure under load, a correction shall be applied for variation of the furnace exposure from that prescribed, where it will affect the classification, by multiplying the indicated period by two-thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three-fourths of the period and dividing the product by the area between the standard curve and a base line of 60◈F (20◈C) for the same part of the indicated period, the latter area increased by 54 Fahr-hour or 30 Cent- hour (3240 Fahr-minutes or 1800 Cent-minutes) to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For fire exposure in the test higher than standard, the indicated resistance period shall be increased by the amount of the correction and be similarly decreased for fire exposure below standard.

NOTE: The correction can be expressed by the following formula:

$C + 2\,1 \quad (A * A\,S)$

3 (*A S*) *L*)

WHERE:

C = correction in the same units as 1 1 = indicated fire endurance period *A* = area under the curve of indicated average furnace temperature for the first three-fourths of the indicated period *AS* = area under the standard furnace curve for the same part of the indicated period *L* = lag correction in the same units as *A* and *AS* (54 Fahr- hour or 30 Cent-hour-3240 Fahr-minutes or 1800 Cent-minutes) (e) **Furnace Pressure.** The pressure in the furnace chamber during the fire test shall be maintained as nearly equal to atmospheric pressure as possible. Horizontal furnaces may be operated at a slight negative pressure sufficient to reduce haze permitting visual observation. Furnace stacks shall be equipped with dampers to facilitate maintenance of furnace pressure.

Correlation Sec. 12-7-305. Tests of specific assemblies of materials shall be conducted for correlation (or correlation factor) of furnace exposure by comparison with tests of identical assemblies and materials conducted in furnaces of "Approved Listing Agencies" which furnaces are deemed as conforming to the design and operating requirements of this standard.

Correlation tests of wall furnaces shall include tests of two assemblies, one combustible and one noncombustible.

Correlation tests of horizontal furnaces dependent on intended test specimens shall include at least one test for each type of assembly such as combustible ceiling-floor assembly, noncombustible assembly having a high thermal capacity floor for heat dissipation, noncombustible assembly having an insulating concrete floor or other type of design.

Comparison of test results shall provide evidence of equivalent exposure based on transmitted temperatures on the unexposed side, on structural framing members, on the underside of floor or roof decks, and in the plenum space.

TABLE 12-7-3A-STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS

TIME	AREA ABOVE 68◈F BASE						AREA ABOVE 20◈C BASE					
	TEMPERATURE											
	Fahr.		Fahr. Min		Fahr. Hour		Cent.		Cent. Min		Cent Hour	
0:00		68		00		0		20		00		0
0:05	1	000	2	330		39		538	1	290		22
0:10	1	300	7	740		129		704	4	300		72
0:15	1	399	14	150		236		760	7	860		131
0:20	1	462	20	970		350		795	11	650		194
0:25	1	510	28	050		468		821	15	590		260
0:30	1	550	35	360		589		843	19	650		328
0:35	1	584	42	860		714		862	23	810		397
0:40	1	613	50	510		842		878	28	060		468
0:45	1	638	58	300		971		892	32	390		540
0:50	1	661	66	200	1	103		905	36	780		613
0:55	1	681	74	220	1	237		916	41	230		637
1:00	1	700	82	330	1	372		927	45	740		762

1:05	1	718	90	540	1	509		937	50	300		838
1:10	1	735	98	830	1	647		946	54	910		915
1:15	1	750	107	200	1	767		955	59	560		993
1:20	1	765	115	650	1	928		963	64	250	1	071
1:25	1	779	124	180	2	070		971	68	990	1	150
1:30	1	792	132	760	2	213		978	73	760	1	229
1:35	1	804	141	420	2	357		985	78	560	1	309
1:40	1	815	150	120	2	502		991	83	400	1	390
1:45	1	826	158	890	2	648		996	88	280	1	471
1:50	1	835	167	700	2	795	1	001	93	170	1	553
1:55	1	843	176	550	2	942	1	006	98	080	1	635
2:00	1	850	185	440	3	091	1	010	103	020	1	717
2:10	1	862	203	330	3	389	1	017	112	960	1	882
2:20	1	875	221	330	3	689	1	024	122	960	2	049
2:30	1	888	239	400	3	991	1	031	133	040	2	217
2:40	1	900	257	720	4	295	1	038	143	180	2	386
2:50	1	912	276	110	4	602	1	045	153	390	2	556
3:00	1	925	294	610	4	910	1	052	163	670	2	728
3:10	1	938	313	250	5	221	1	059	174	030	2	900
3:20	1	950	332	000	5	533	1	066	184	450	3	074
3:30	1	962	350	890	5	848	1	072	194	940	3	249
3:40	1	975	369	890	6	165	1	079	205	500	3	425
3:50	1	988	389	030	6	484	1	086	216	130	3	602
4:00	2	000	408	280	6	805	1	093	226	820	3	780
4:10	2	012	427	670	7	128	1	100	237	590	3	960
4:20	2	025	447	180	7	453	1	107	248	430	4	140
4:30	2	038	466	810	7	780	1	114	259	340	4	322
4:40	2	050	486	560	8	110	1	121	270	310	4	505
4:50	2	062	506	450	8	441	1	128	281	360	4	689
5:00	2	075	526	450	8	774	1	135	292	470	4	874
5:10	2	088	546	580	9	110	1	142	303	660	5	061
5:20	2	100	566	840	9	447	1	149	315	910	5	248
5:30	2	112	587	220	9	787	1	156	326	240	5	437
5:40	2	125	607	730	10	129	1	163	337	630	5	627
5:50	2	138	628	360	10	473	1	170	349	090	5	818
6:00	2	150	649	120	10	819	1	177	360	620	6	010
6:10	2	162	670	000	11	167	1	184	372	230	6	204
6:20	2	175	691	010	11	527	1	191	383	900	6	398
6:30	2	188	712	140	11	869	1	198	395	640	6	594
6:40	2	200	733	400	12	223	1	204	407	450	6	791
6:50	2	212	754	780	12	580	1	211	419	330	6	989
7:00	2	225	776	290	12	938	1	218	431	270	7	188
7:10	2	238	797	920	13	299	1	225	443	290	7	388
7:20	2	250	819	680	13	661	1	232	455	380	7	590
7:30	2	262	841	560	14	026	1	239	467	540	7	792

7:40	2	275	863	570	14	393	1	246	479	760	7	996
7:50	2	288	885	700	14	762	1	253	492	060	8	201
8:00	2	300	907	960	15	133	1	260	504	420	8	407

FIGURE 12-7-3-1-TIME-TEMPERATURE CURVE

FIGURE 12-7-3-1